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Lactation Curve of Temperate Friesians on Smallholder Farms in Tropical Central Uganda

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Abstract: The hypothesis that environmental constraints in the warm tropical Central Uganda depress milk production of Friesians on smallholdings was tested using records from 85 small farms around Kampala. Daily Milk Yield (DMY), Lactation Milk Yield (LMY) and the shape of the lactation curve were compared with those of a typical Friesian cow in the temperate zones. Differences yields of shaded/Zero Grazed (ZG) and non-shaded/Open Grazed (OG) cows demonstrated the microenvironment effect on performance. Nutrition effects were evaluated by comparing the variation of monthly DMY with that variation in monthly total rainfall. Lactation curves were generated by plotting mean DMY against time in months after calving. The overall mean DMY and LMY/cow/day of lactation were 60 and 65%, respectively of those of a Friesian in the temperate zone. The lactation curve of Friesians in Central Uganda was characterised by a transient peak followed by a consistent drop in daily yield compared to the typical lactation curve of a temperate dairy cow that is characterised by a peak at 5-6 weeks followed by a gradual decline. ZG cows had longer lactation lengths, higher LMY and higher DMY than OG cows. Least squares mean DMY was 12.8±0.1L and 10.6±0.1L litres for ZG and OG cows respectively. So, environmental constraints depress production of Friesians on small farms in Central Uganda and although cows may benefit from shading, production is generally below the genetic potential of the Friesian genotype.

Key words: Stress, environment, milk yield, lactation curve, smallholder farms, DMY, LMY, OG, ZG

INTRODUCTION

Central Uganda is promoting smallholder Friesian dairying to enhance household food security and incomes. Friesian breeds are selected because of their ability to produce more milk than the indigenous breeds. A major limiting factor to dairying is a stressful environment. Animals respond to changes in the environment immediately surrounding them (Robertshaw, 1981) including nutritional and management regimens to determine the animals' production level (Beede *et al*., 1985). Thus, if there were environmental constraints in central Uganda, one would expect them to be reflected in terms of depressed production and reproductive efficiency of the cows. The shape of the lactation curve has been used to demonstrate depressed performance resulting from environmental constraints. The lactation curve gives an understanding of the production system, its associated limitations and assesses cows and/or herds (Madalena *et al*., 1979). The influence of environment on performance of animals can also be demonstrated by comparing two microclimates like those existing at open grazing farms and zero grazing units (Roman-Ponce *et al*., 1977; Ingraham *et al*., 1979; Buffington *et al*., 1983; Davison *et al*., 1988). Due to the fact that zero grazed cows are continuously protected from direct solar radiation, they may be subject to less total heat load than open grazed cows which are not protected all the time. In tropical Hawaii, where the climate is almost similar to that of central Uganda (daily temperature ranges from 22-29°C) cows kept under sheet-metal shades produced more milk and milk fat and had less mastitis test scores than those that were given no shade (Ingraham *et al*., 1979). In the tropical Atherton tablelands (Davison *et al*., 1988), cows without access to shade had significantly higher somatic cell counts that those with access to shade. In Florida, cows that did not have shade during summer had lower conception rates compared to those with shade (Buffington *et al*., 1983).

Additionally, the climatic effects on performance can be assessed by correlating seasonal variations notably of nutrition, via rainfall with performance parameters (Stott, 1981). These environmental factors have not been considered in the context of peri-urban dairying in central

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Uganda, which is relatively new with the majority of the farms having started in the late 1980s. Because, the farming system is a low external input one, it implies that even when farmers manage to provide the required nutritional and health demands of the animals, they cannot provide a thermo neutral environment for the Friesian genotype because the technological inputs required to provide it are very costly. These arguments lead to the hypothesis that environmental constraints depress milk production of Friesians on smallholdings in central Uganda.

MATERIALS AND METHODS

In order to test the hypothesis that milk production is depressed, the shape of the lactation curve was compared with that of a typical Friesian cow in the temperate zones. In this way, the effect of environment on milk productivity of Friesians in central Uganda was described. Differences in performance parameters of shaded (zero grazed) and non-shaded animals (open grazed) were used to demonstrate the microenvironment effect on performance. Lastly, the effects of nutrition were evaluated by comparing the variation of monthly mean DMY with that of the monthly total rainfall. The data used to carry out these analyses was collected from farmers' records during the farm surveys. Only 85 of the 108 farms were used to provide records for 191 cows for analysis. This sample size was based on the guideline for determining an appropriate sample size, which is elaborated in more detail.

Determination of right sample size of animals and/or observations required for each of the performance parameters was determined before carrying out the survey. This was done to ensure that representative sample size data for each parameter would be collected. The sufficient sample size required for the determination of mean milk yields, calving interval and duration before postpartum resumption of oestrus was obtained using the guideline for determination of a sufficient sample size as indicated in formula.

$$n = k\,(c/d)^2$$

Where,

- n : Represents the required sample size.
- k : Is a constant depending on the significance level and probability of detecting a difference, c stands for the coefficient of variation (%) of the sample population.
- d : Is the important difference between the group means to be detected or the level of significance given as a % of the mean.

Table 1: The sample sizes required for the determination of different performance parameters in smallholder farms around Central Uganda

Parameter	Mean from literature	Coefficient of variation	Required sample size
First oestrus post partum (days)♦	57.1	5.0	26
Days open♦	176.4	3.9	15
Overall calving interval◊	400.9	24.0	599
1st lactation milk yield◊	2700.0	18.9	371
2nd lactation milk yield◊	3295.0	25.0	650
3rd lactation milk yield◊	3256.0	19.5	396
Overall lactation yield (kg)◊	2982.0	23.4	570

♦ = Romàn-Ponce (1987); ◊ = Trail and Marples (1968)

For this study, the probability of detecting a difference was set at 95% and at a significance level of 5%, which implied that the corresponding k value was equal to 26. This formula was applied to figures from the literature by Romàn-Ponce (1987) and Trail and Marples (1968) to determine the appropriate sample sizes to be used in the estimation of performance parameters in Holstein Friesians in Central Uganda as shown in Table 1.

For the analysis of production of the smallholder Friesian cows, 4455 monthly total milk yield records from 170 cows and 345 cow-parities were collected and used to analyse daily milk production, lactation curves and total lactation yields. Because not all cows calve at the beginning or at the very end of the month, mean Daily Milk Yields (DMY) for each cow were obtained by dividing the total monthly yield by the number of days milked during that month. The fixed effects of management system, parity, stage of lactation (month after calving), calendar month and year on DMY were examined with an F-test under the GLM procedure.

Similarly, the effect of management system, parity and number of days milked as independent variables on total Lactation Milk Yields (LMY) were tested under GLM procedure. Because the number of records between two management systems of parities was not the same, comparing least squares means using a t-test, tested differences in subclasses of significant independent variables. To obtain lactation curves, mean DMY was plotted against time in months after calving. The resultant curves were compared to that of a Friesian cow in the temperate zones. The typical lactation curve of a temperate dairy cow is characterised by a peak at 5-6 weeks followed by a gradual decline in production (Wood, 1967). The relation between milk production and the time after calving is described by the mathematical expression below according to Wood (1967, 1969).

$$y_t = at^b e^{-ct}$$

or the logarithmic form:

$$\log y_t = a + b\log t - ct$$

Where; y is the DMY at a given time t, a is a scaling factor fixing the height of the curve and relates to the average production level of the herd and specific potential of individual cows. The constant b represents the increasing slope while the constant c represents the decreasing slope of the lactation curve.

Using constants obtained from Whittemore (1980) a theoretical curve for a Friesian cow in the temperate region was drawn. In order to predict the Wood curve from the milk yield of the Ugandan Friesian, the parameters a, b and c had to be obtained first. They were obtained by performing a multiple linear regression analysis of log y on t and log t. The predicted shape of the lactation curve was compared to that of the actual shape and that of a Friesian cow in the temperate region. However, because shape of the lactation curves of European breeds of cows in the tropical regions have been found to be linear or to have a very flat peak (Madalena *et al*., 1979; Guo and Swalve, 1997), it was also necessary to see if the lactation curve of the Friesians around Central Uganda would be better described by prediction formulae other than that of Wood. For instance, the Guo and Swalve curve expressed as

$$Y_t = a_1+a_2\sqrt{t}+a_3t+a_4t^3+a_5t^{\log t}$$

Where Y_t is the daily milk yield on the day t, a is the parameter associated with peak yield and log t is the log function of day t, was found to describe lactation curves of Friesians in Malawi better than the Wood curve (Chagunda, 2000).

RESULTS

The milk production of Friesian cows around Central Uganda compared to that of temperate cows is presented in Table 2. The overall mean DMY per cow per day of lactation was 60% of that of a Friesian in the temperate zone. The mean LMY was only 65% of that for a Friesian in the temperate zone despite the fact that the mean lactation length of the central Uganda Friesian was 10% longer than that of the temperate cow (Bourchier *et al*., 1987; Grothe, 1993; Payne and Wilson, 1999).

The lactation curve of the Central Uganda Friesians was characterised by a transient peak followed by a consistent drop in daily yield. No differences were seen between using Wood's or Guo and Swalves' formulae to predict the lactation curve of Friesians in this area (Fig. 1).

Table 2: Milk production of Friesian cows from 1990-1999 compared with Friesians in the temperate zone

System	Lactation yield (ltr)	Lactation length (days)	DMY
Overall	3929	338	11.7
Temperate	6050	305	19.8

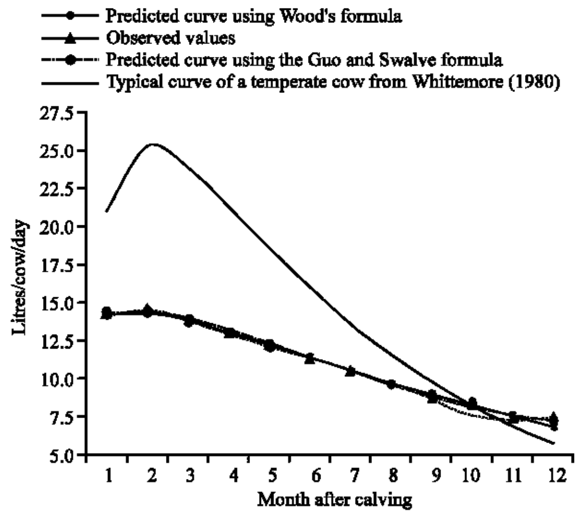

Fig. 1: Lactation curves of Friesians on peri-urban smallholder farms in Central Uganda, 1990-1999

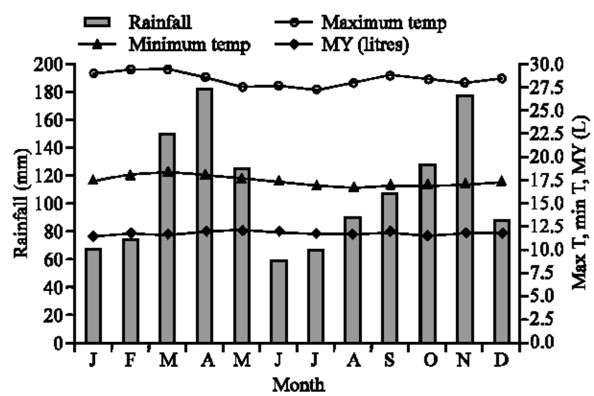

Fig. 2: Mean monthly milk yield per cow on smallholder farms and mean values of the climatic parameters 1969-99) that influence seasonality in Central Uganda

The differences between lactation curve of Friesians around Central Uganda and a temperate cow can are shown in Fig. 1. Applying Wood's formula to obtain constants, the shape of the lactation curve of Friesians in Central Uganda is described as

$$y_t = 2.749t^{0.166}e^{-0.103t}$$

That of a temperate Friesian cow, using constants from Whittemore (1980) is described as

$$y_t = 3.306t^{0.49}e^{-0.232t}$$

Where t is time in months after calving.

Daily Milk Yield (DMY) was significantly influenced by management system, year, parity, stage of lactation,

Table 3: Total lactation yield and length in open and zero grazed cows from 1990-1999

	Lactation yield (litre)		Lactation length (days)	
System	Mean	SE	Mean	SE
Zero	4083	97	360	116
Open	3550	96	300	76

t-test significance p = 0.0001

the cow and the interaction effect of the year with management system and stage of lactation (p = 0.0001). The significant effects accounted for 46% of the total variation of DMY. After correcting for the effects of year, parity, stage of lactation, the cow and their interaction effects, zero grazed cows had a least squares mean daily milk yield of 12.8 (se = 0.1) while open grazed cows had 10.6 (se = 0.1) litres (p = 0.0001). Season and calendar month were found to have no effect on mean DMY. However, in April and May there was a small but significantly higher DMY than in January ($p<0.05$), the month that recorded the lowest daily yield. Despite major differences in the amount of rainfall (therefore forage growth) during the other months of the year, no differences in DMY were recorded between those months. The pattern of daily milk yield and the monthly rainfall pattern are shown in Fig. 2.

When months of year were grouped into the dry and wet seasons, no differences in daily milk yields were found between dry and wet seasons. However, calving season had a significant influence on the daily yield ($p<0.01$), whereby cows calving during wet season had 0.5 litres less than cows calving during the dry season ($p<0.01$).

The LMY was significantly affected by management system, parity, total number of days milked and the random effect of the cow, all at p = 0.0001. Zero grazed cows had a significantly longer lactation lengths and a higher lactation yield than open grazed cows. The differences in the two traits between zero and open grazed cows are summarised in Table 3.

DISCUSSION

This study has shown environmental stress lowers milk production of the Friesian on small farms in the tropical warm climate of central Uganda to below the genetic potential of the Friesian genotype. The first indication of this that the lactation curve was similar to curves elsewhere in the tropics (Madalena *et al*., 1979) with the constants a and b for the lactation curve of the Ugandan Friesian being lower than those of a Friesian in the temperates These low constants cause the initial yield, the rise to peak yield and consequently the general production level to be lower than those of a temperate cow (Fig. 1). The constant c shows that after the initial peak, the rate of decline in milk yield, which also reflects rate of decline in cell number and activity, is slower in the Ugandan Friesian cow than in the temperate cow. This slow rate of decline, though may be desirable, also reflects a generalised low level of protein intake by these animals (Chamberlain, 1993). From Fig. 1, one can deduce that comparison of the Ugandan lactation curve with that of a cow in the temperates was justified because the curves drawn after Wood (1967) or Guo and Swalve (1997) were in agreement with that of the observed milk yields.

The second indication is the finding that after correcting for the effects of year, parity, stage of lactation, the cow and their interaction effects, zero grazed cows had a least squares mean daily milk yield of 12.8L while open grazed cows had 10.6L (p = 0.0001). This demonstrates that shade in this area is beneficial to the productivity of the cows as has been observed elsewhere, (Ingraham *et al*., 1979; Buffington *et al*., 1983; Davison *et al*., 1988).

Contrary to the impression that daily milk production in this area may be following rainfall patterns (MAAIF, 1992; ILRI, 1996), no seasonality was seen in the daily milk yields. This was despite the presence of two clear rainy seasons during which there is plenty of forage and two dry seasons, when forage was probably inadequate and of low quality. Although, this may mean that farmers managed to maintain milk yields during the unfavourable hot dry season it also implies that there is no time to make up for the generally low production. Nutrition, which is known to play a central role in productivity of animals, could have indirectly influenced the overall productivity without clear-cut seasonal responses to the weather pattern. This is in line with the flat curve after the initial peak, which is attributed to generalised low level of protein intake. During the rainy months when there is plenty of good quality forage, no significant improvements in production were observed, implying that during such times, something other than nutrition must be affecting productivity even during the times when Nutrition is not limiting. From the climatic description of this region (Fig. 2), it can be shown that throughout the year, daily maximum temperatures are above 21°C, which is comfortable for Friesian dairying and even above the upper limit of 25°C above which significant reductions in milk yield occur (Johnson *et al*., 1962; Hahn and McQuigg, 1967). This constant climatic stress may explain the failure to have significant changes in milk yield during rainy and dry seasons during the year, the low general production level, initial yield and rate of rise to peak yield of the lactation curve.

CONCLUSION

It is concluded that although production of Friesians on small farms in Central Uganda may benefit from shading it is generally below the genetic potential of the Friesian genotype. The suitability of Friesians as the breed of choice for improvement of livelihoods in Central Uganda hence needs further investigations.

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